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PRELIMINARY STUDY OF MICROSTRUCTURE DEPENDENCE OF MAGNETORESISTANCE BEHAVIOR ON $Sm_{1-X}La_XMn_2Ge_2$ COMPOUND WITH X=0,1~0,3

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ABSTRACT

PRELIMINARY STUDY OF MICROSTRUCTURE DEPENDENCE OF MAGNETORESISTANCE BEHAVIOR ON $Sm_{1-x}La_xMn_2Ge_2$ COMPOUND WITH x=0.1~0.3. We present the microstructure dependence of magnetoresistance behavior in $Sm_{1-x}La_xMn_2Ge_2$ compound with x=0.1~0.3. We found that in bulk samples after milling and cold pressing P=10 ton/cm^2 the magnetoresistance properties have improved from 0.6% to almost 7% with the adding of La concentration 10%,20% and 30%. The bulk samples were prepared by tri arc melting, melted 4-5 times with the Ti addition for oxygen getter. After that, the samples were annealed for 96 hours at 900 °C at the vaccum furnace to make a good homogeneity. X-ray diffraction measurement was done using Cu target then the data was refined by Rietan software. Scanning electron micrograph data a pellet samples were taken by SEM 515 from Phillips company with two thousands magnification and operation power 20keV. From the micrograph results, it was shown that the granular diameter increases with the Lanthanum content. In this preliminary study we can conclude the magnetoresistance behavior is related to the density of samples and also to the fraction of primary phase of $Sm_{1-x}La_xMn_2Ge_2$. Analysis on this magnetoresistance behavior with magnetic granular solid model can help understanding this phenomenon.

ABSTRAK

STUDI PENDAHULUAN HUBUNGAN ANTARA MIKROSTRUKTUR DENGAN SIFAT MAGNETO RESISTANSI PADA $Sm_{1-x}La_xMn_2Ge_2$ UNTUK x = 0,1~0,3. Pada makalah ini disampaikan hasil penelitian awal tentang ketergantungan sifat magnetoresistance bahan terhadap strukturmikro pada paduan in $Sm_{1-x}La_xMn_2Ge_2$ dengan x = 0,1~0,3. Hasil pengukuran pada cuplikan pelet pada tekanan P=10 ton/cm^2 memperlihatkan kenaikan sifat magnetoresistance bahan dari 0,6 % menjadi 7 % dengan penggantian unsur Sm oleh unsur La pada konsentrasi 10 %, 20 % dan 30 %. Pembuatan cuplikan dilakukan dengan metoda *tri arc melting*, yang dilakukan sebanyak 4 sampai 5 dengan Ti yang dilebur terlebih dahulu sebagai penyerap oksigen. Setelah itu cuplikan dianil selam 96 jam pada suhu 900 °C dalam *furnace vakum*. Kemudian dilakukan pengukuran difraksi sinar-X dan hasilnya dihaluskan dengan software RIETAN. Studi strukturmikro dilakukan dengan memakai alat SEM 515 buatan PHILIPS pada perbesaran 2000 kali dan tegangan 20 keV. Hasil pengamatan tadi memperlihatkan bahwa terjadi perbesaran diameter *granular* sesuai dengan penambahan kadar unsur La. Pada awal studi ini dapat disimpulkan bahwa sifat magnetoresistance bahan tergantung pada kerapatan bahan, ukuran *granular* dan fraksi fasa utama $Sm_{1-x}La_xMn_2Ge_2$. Analisis sifat magnetoresistance dengan *model magnetic granular* solid dapat menjelaskan fenomena proses hamburan yang terkait dengan sifat resistansi bahan.

1. INTRODUCTION

The large application potential of magnetoresistance material has recently motivated extensive studies of resistivity changes due to the reorientation of magnetic moments in various materials when external magnetic field applied. Since the discovery of the giant magnetoresistance (GMR) in multilayers, a progressive research effort has been focusing on these artificially fabricated structures, in which local magnetization directions can be rotated in moderate magnetic fields. But in this work we try a *nonmultilayer* magnetic media to investigate the magnetoresistance behavior in naturally layered-structured materials. That material is $(Sm,La)Mn_2Ge_2$, crystallize in a simple structure of $ThCr_2Si_2$ type[1]. The atoms Sm or La , Mn and Ge occupy the 2(a), 4(d) and 4(e) sites, respectively. Then, atoms of the same element lie on the alternate layers stacked along the c-axis according to the sequence Sm – Ge – Mn - Ge – Sm. Based from magnetization study, Narasimhan[2] and Szytula and Scott[3] concluded that $SmMn_2Ge_2$ is a ferromagnetic with the Curie temperature 350K. Magnetic characterization of the single crystal $SmMn_2Ge_2$ show that ferromagnetism is present in the temperature range of 196K<T<348K, collinear antiferromagnetism becomes stable for 64K<T<196K and re-entrant ferromagnetism appears below 64K[4].

The present paper describes the results of systematic investigation of the effect of La substitution for Sm in $SmMn_2Ge_2$ on the magnetic properties such magnetoresistance behavior. Our hypothesis is La substitution into Sm position make change the magnetic properties like magnetic phase or structure, then of course the magnetoresistance properties.

2. EXPERIMENTS

The samples were prepared by arc melting techniques. The purity was 3N for Sm or La, 4N for Mn and 5N for Ge. The sample was melted 4-5 times and annealed for 96hours at 900 Celsius and cooled down to room temperature.

X-ray diffraction studies on powdered samples were carried out by means of the Shimadzu diffractometer operating with Cu radiation.

The temperature and external magnetic field dependence of magnetization curve were measured by VSM (Vibrating sample Magnetometer) with external field 0.96 kOe and 10kOe. Magnetoresistance behavior was studied by home made dc four point probe with external magnetic field up to 1.2Tesla. Then, microstructure studies were performed by SEM Phillips 515.

3. RESULTS AND DISCUSSION

X ray diffraction measurement

The X-ray diffraction pattern at room temperature exhibits lines characteristic for tetragonal body-centered structure of the $ThCr_2Si_2$ type[1], with a slight La_2O_3 phase present as impurity. The complete refinement results by RIETAN software were shown in Table 1.

Table 1. X-ray Refinement results

Compound	Formed Phase (weight %)
$Sm_{0.9}La_{0.1}Mn_2Ge_2$	$Sm_{0.9}La_{0.1}Mn_2Ge_2$ = 91.13% -La_2O_3 = 8.87%
$Sm_{0.8}La_{0.2}Mn_2Ge_2$	- $Sm_{0.8}La_{0.2}Mn_2Ge_2$ = 99.93% - La_2O_3 0.7%
$Sm_{0.7}La_{0.3}Mn_2Ge_2$	-Sm0.7La0.3Mn2Ge2 = 99.93% - La_2O_3 = 0.7%

3.1. Magnetization measurement

Figure 1 and 2 were shown the temperature and external magnetic field dependence of the magnetization phase behavior from compound with La=0.3, respectively. From figure 1, two magnetic phases appear: first, at 4.2~150K, is ferromagnetic and second, at 150K~350K, is ferrimagnetic phase. The presence of these two phases

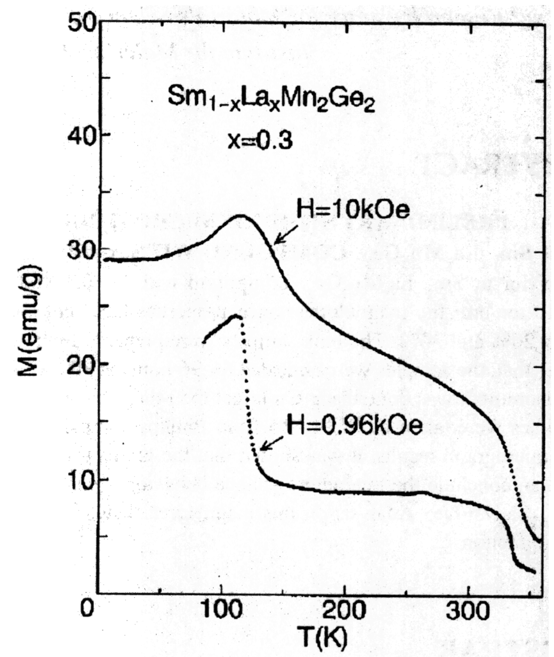

Figure 1. Temperature dependence of magnetization curve of $Sm_{0.7}La_{0.3}Mn_2Ge_2$ at H=0.96 and 10kOe.

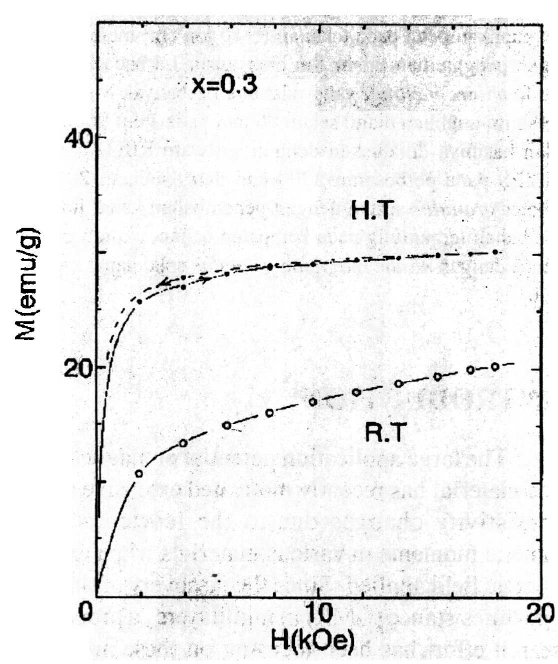

Figure 2. External magnetic field dependence of magnetization curve for $Sm_{0.7}La_{0.3}Mn_2Ge_2$ at T=4.2K and Room Temperature.

is confirmed by the M-H measurements done at 4.2K and at Room temperature as shown from Figure 2. Our another result is the increasing of La content causes the intermediate phase broadening. This phenomenon is due to the change of exchange interaction between Sm-Sm and Sm-Mn magnetic moment and consistence with our result in $(Tb,Y)Mn_2Ge_2$ compound[5].

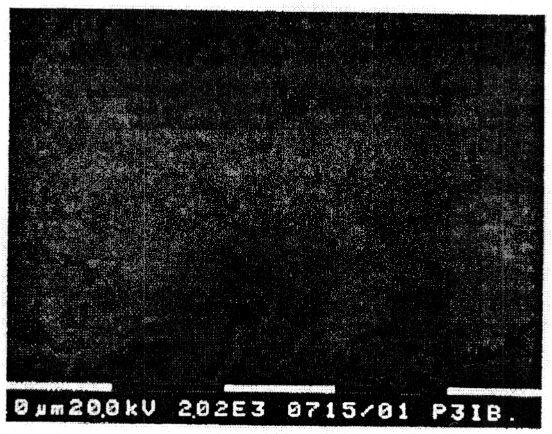

Figure 3. Electron Micrograph of $Sm_{0.9}La_{0.1}Mn_2Ge_2$ granular diameter almost smaller than 5~10 mm.

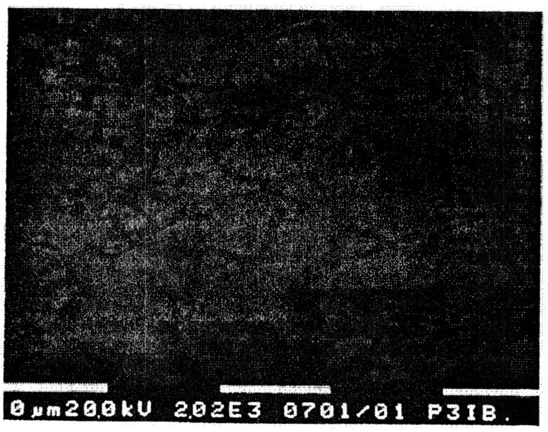

Figure 4. Electron Micrograph of $Sm_{0.8}La_{0.2}Mn_2Ge_2$ granular diameter mostly between 5~10 mm.

Figure 5. Electron Micrograph of $Sm_{0.7}La_{0.3}Mn_2Ge_2$ granular diameter mostly bigger than 10 mm.

3.2. Microstructure measurement

Microstructure behavior of the pellet samples $Sm_{1-x}La_xMn_2Ge_2$ was characterised by Scanning Electron Microscope (SEM). The electron micrograph shows the difference in granular diameter among the three samples of x=0.1, 0.2 and 0.3, respectively. Figure 3~5 were shown the electron micrograph of that samples.

3.3. Magnetoresistance measurement

The most important result in our present study is the behavior of Magnetoresistance properties at room temperature. Our results show that the Magnetoresistance is related to the content of primary phase of $(Sm,La)Mn_2Ge_2$, density of samples and diameter of granular.

Table 2 has shown the result of dependence of magnetoresistance ratio (difference between resistivity at H=0 and H=H-critical) related to the primary phase, density and diameter of granular from each compound.

Table 2. Magnetoresistance measurement results related to microstructure behavior.

Compound	Density (gr/cc)	Granular diameter (µm)	Magneto-resistance Ratio (%)
$Sm_{0.9}La_{0.1}Mn_2Ge_2$	7.08	<5~10	0.6
[illegible]	5.85	5~10	1.4
$Sm_{0.7}La_{0.3}Mn_2Ge_2$	6.13	·10	7.0

One analysis for sample La=0,3 with magnetic granular solid model[6,7] can fit the experiment result with parameter model as shown in Figure 6. From fitting result it can be concluded that the presence of La make the result of fitting for higher degree of scattering electron at high magnetic field (diamond dot) coincident with the experiment data.

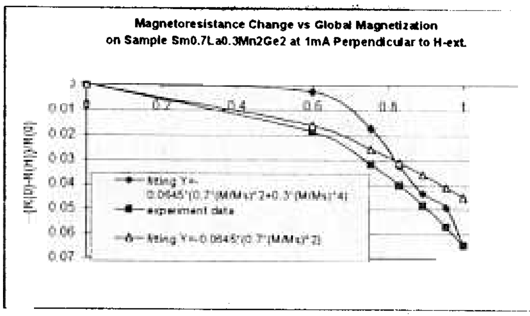

Figure 6. Fitting results for magnetoresistance measurement result with magnetic granular solid model.

Otherwise fitting model for lower degree of scattering electron (sign by triangle dot) only coincident with experiment data at range low magnetic field. From that result we can conclude that the homogeneity of granular diameter, density and weight % of primary phase contribute to the behavior of magnetoresistance in this compound.

4. CONCLUSION

In this preliminary study we concluded that the behavior of magnetoresistance of pellet samples depend to weight % of primary phase of sample, diameter of granular and density of the sample. Analysis with magnetic granular solid model could explain the magnetoresistance phenomenon. The sample with more homogenous granular diameter may improve the magnetoresistance ratio. Further study on sintered samples now in progress.

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